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SODIUM CONDITIONING TO REDUCE FLY ASH RESISTIVITY

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SECTION I

INTRODUCTION

The resistivity of fly ash is often too high under a particular set of operating conditions to permit the most efficient use of an electrostatic precipitator. A variety of substances, generally referred to as conditioning agents, can be added to the boiler or to the effluent gas downstream to attenuate the high resistivity.

Research has shown that sodium is the principal charge carrier in the electrical conduction process through an ash layer at temperatures above 250°C. This observation suggests that sodium might be utilized as a conditioning agent. This report briefly reviews this point in a pragmatic manner.

SECTION II

BACKGROUND

For a given ash layer porosity and temperature, it has been observed that the resistivity is inversely proportional to the amount of sodium and lithium present in the ash.[1] A log-log plot of resistivity versus the atomic concentration of lithium plus sodium shows approximately a two order of magnitude decrease in resistivity for a one order of magnitude increase in lithium-sodium concentration. This relationship is shown in Figure 1 for a specific temperature and ash layer porosity.

Transference experiments gave direct evidence that these two elements were the principal charge carriers in the volume conduction process. This information combined with ash characterization studies that indicated the major constituent in fly ash is amorphous lead to the conclusion that conduction in fly ash is analogous to that of silicate glass. Additional research[2] has verified the above results and expanded the knowledge pertaining to the compositional factors that influence the electrical resistivity of fly ash.

The analysis of very recent data[3] has shown that surface resistivity also is governed at least in part by the aforementioned chemical effects. This was the expected observation. If fly ash possesses a conduction mechanism analogous to silicate glass, the surface resistivity should be sensitive to the alkali metal content.

Two field tests were conducted in which sodium conditioning was attempted. Operational temperatures were between 140°C and 175°C, the range in which surface conduction should dominate. Both were technically successful in that the resistivity was reduced the predicted amount by the addition of sodium. However, neither of the two power stations are using sodium conditioning. One

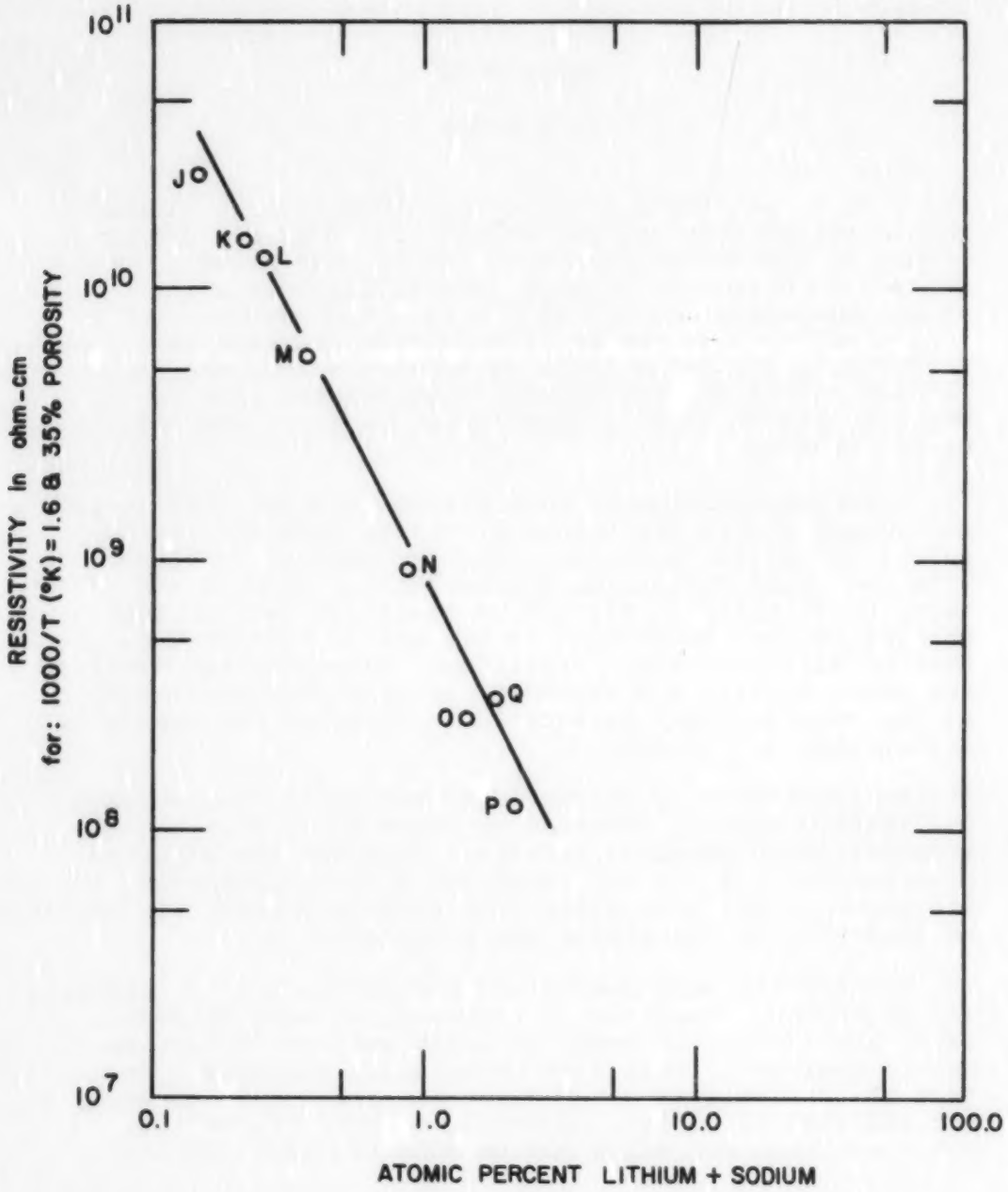

Figure 1. Resistivity vs Atomic Percent Lithium and Sodium at a Specific Temperature and Ash Layer Porosity

concluded it was not an economical approach for them and are continuing their search for a conditioning agent. The other company elected to build a hot side precipitator in an effort to be independent of conditioning agents. A portion of these field tests conducted by Southern Research Institute and Calgary Power Limited of Calgary, Alberta, Canada were recently reviewed.[4]

SECTION III

AN APPROACH TO SODIUM CONDITIONING

AMOUNT OF Na_2O ADDITION

The combined atomic percentage of lithium and sodium was used to establish a correlation between resistivity and these elements for a great number of ashes. In applying this information for the attenuation of resistivity for a given ash, the weight percent of sodium oxide can be used satisfactorily. Since there always is some disparity among resistivity data and since a wide range of operational temperatures are employed, the correlation between resistivity and sodium oxide concentration is shown below algebraically rather than graphically.

$$\rho_1/\rho_2 = (w_2)^2/(w_1)^2 \qquad (1)$$

ρ_1 = measured resistivity in ohm-cm
ρ_2 = desired resistivity in ohm-cm
w_1 = measured weight percent Na_2O in ash
w_2 = required weight percent Na_2O in ash

Example: Assume a measured resistivity of $1x10^{12}$ ohm-cm at a given set of operating conditions for an ash containing 0.30 weight percent Na_2O. Assume it is desired to reduce the resistivity to $5x10^{10}$ ohm-cm under the same operating conditions.

Then:

$$(w_2)^2 = \frac{1x10^{12}}{5x10^{10}} \times (0.30)^2 \quad \text{and} \quad w_2 = 1.34 \text{ weight percent}$$

If the value of w_2 reaches 3.0 weight percent, there would be reason to believe that the measured values for resistivity and/or Na_2O are in error.

This example calculation indicates that the sodium oxide concentration in the ash should be increased by 1.04 weight percent. If the hypothetical plant is producing 10,000 pounds of ash per hour and selects Na_2CO_3 (58.5% Na_2O) as a source of Na_2O, the sodium carbonate would be required at a rate of 178 pounds per hour.

SOURCE OF Na_2O ADDITION

Since it is believed that for sodium to function properly it must be an integral part of the fly ash, the substance used to supply the Na_2O must be one that decomposes, vaporizes, or melts at boiler temperatures. The source material should not nocuously affect equipment or the environment. Beyond these two points, the selection of a material as a source of Na_2O becomes an economic compromise searching for the lowest cost per pound of sodium oxide added. Factors that must be considered include: availability of low grade-low cost materials, transportation, percentage of Na_2O supplied by the substance, etc.

Potential compounds that can be considered as sources of Na_2O include: Na_2CO_3, Na_2SO_4, NaOH, $NaNO_3$, etc. Because of the deleterious effects due to chlorine, NaCl cannot be used; however, one might consider salt as a raw material used to produce a suitable additive. With respect to cost, the plant operator may wish to consult with chemical houses to determine if a usable substance might be obtained in an impure state at some stage of production.

METHOD AND LOCATION OF ADDITION

To insure that the sodium becomes an integral part of all the ash, the source of sodium should be uniformly distributed throughout all of the coal feed. If the source material is water soluble, the addition can be made either dry or as a water spray. Wet or dry feeders having suitable capacity are commercially available.

SECTION IV

ADVANTAGES AND DISADVANTAGES

The advantages can be summarized as: small capital investment, low labor cost for operation and maintenance, no obvious safety or materials handling problems, and the amount of source material fed can be easily adjusted to compensate for the changes in sodium level of incoming coal.

The disadvantages are source material cost and potential boiler fouling. Whether or not material cost inhibits the use of sodium conditioning depends on several factors including: the amount required, the availability of low-cost (impure or partially processed) forms of source materials, and the distance the material must be transported.

Ash fouling particularly related to lignites has been reported[5] and related to sodium concentration. This is generally associated with ashes containing either a very high sodium concentration or a moderate sodium concentration and low fusion temperature. If sodium conditioning is utilized without discretion, fouling could be a problem. The following comments are directed toward this potential problem.

1) From the results of the examination of twenty-five ashes produced from sub-bituminous, bituminous and anthracite coals from the Eastern and Western parts of the U.S.A., the ash having the highest resistivity should require an addition of approximately 2.5% Na_2O to make the resistivity acceptable.

2) Coals yielding ashes inherently containing 2 to 3 percent Na_2O are used without fouling problems.

3) Fouling problems can also be related to the softening and fusion characteristics of the ash. While sodium can depress the fusion temperature of an ash, this characteristic is also dependent upon the amount and ratios of other constituents. Some of these constituents also lower resistivity, reference 2. It would seem unlikely that an ash requiring an attenuation of resistivity would also be subject to fusion problems.

SECTION V

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